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Attachment 2  
IB-OF-A-2002-03  
3/1/2002

## ***Program for Climate, Ecosystem and Fire Applications***



# **Development of Lightning Climatology Information over the Western U.S.**

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Attachment 2



## Forward

This report describes the lightning climatology products for the western United States developed using the National Lightning Detection Network™ lightning dataset. The project was done under Task Order 1422RAH012403 of the Cooperative Assistance Agreement No. 1422RAA000002 between the Bureau of Land Management National Office of Fire and Aviation and the Desert Research Institute Program for Climate, Ecosystem and Fire Applications. For further information regarding this report or project, please contact either:

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Foreword

This report describes the lightning research project for the western United States. The project was developed by the National Lightning Research Institute (NLRI) in cooperation with the U.S. Forest Service, U.S. Department of Agriculture, and the U.S. Department of the Interior. The project was funded by the U.S. Forest Service, U.S. Department of Agriculture, and the U.S. Department of the Interior. The project was a cooperative effort between the U.S. Forest Service, U.S. Department of Agriculture, and the U.S. Department of the Interior. The project was a cooperative effort between the U.S. Forest Service, U.S. Department of Agriculture, and the U.S. Department of the Interior. The project was a cooperative effort between the U.S. Forest Service, U.S. Department of Agriculture, and the U.S. Department of the Interior.

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## Project Objectives

From 1990 and 2000, our analyses of fire occurrence data indicates that between 50% and 75% of all fire starts in the western United States on Bureau of Land Management (BLM) land, depending upon the region, were caused by cloud-to-ground (CG) lightning strikes. Thus, it is desirable to have a better understanding of when and where these lightning strikes occur historically so that fire managers and planners can allocate their resources more effectively, and to provide a knowledge base for meteorologists and other users of climate information. Also, this information is necessary in analyzing climate factors related to seasonal fire activity (e.g., Brown and Hall 2000; 2001). Since 1989 the National Lightning Detection Network™ (NLDN) has been recording information about CG lightning strikes across the U.S. The objective of this project was to develop CG lightning strike climatologies over the continental western U.S. for various time periods, including the annual average, monthly average, and hourly by month average number of lightning strikes.

## Data

Cloud-to-ground lightning strike data for the period 1990 through 2000 were obtained from the National Lightning Detection Network™ maintained by Global Atmospheric, Inc. (GAI). The data set used for the analysis consists of the date, time, latitude, and longitude of the strike. These data are proprietary and were purchased directly from GAI. For further information about NLDN, see Cummins et al. (1998).

## Methods

Climatologies for each time period of interest (i.e., annual, monthly, hourly by month) were computed by dividing the total number of lightning strikes within a grid for the time period by the total number of years (11). The area along the U.S.-Canada border includes three years (1998 – 2000) comprising strike data from Canadian lightning sensors. Eleven years is a relatively short period of record for developing a climatology given the occurrence of decadal and longer climate regimes. Also, with such a short record it is possible that a single thunderstorm that produced an “unusually” large amount of lightning strikes could heavily influence the climatology.

A 0.5 degree spatial grid was used across the western U.S. for each climatological time period. This grid size is somewhat of an arbitrary choice, but it does resolve some coarse terrain features and allows for identifying coherent regions of lightning activity. Annual correction values for 1990-1998 were applied to each grid to improve the climatology counts. These values attempt to correct for known detection efficiency issues across the network during those years based on an algorithm recently developed at GAI (Cummins 2001). Though the correction values are based on annual number of strikes, it is believed that these values can also be applied to the monthly and diurnal climatologies. For the last step of the climatology development, the gridded values were contoured using a Cressman analysis scheme (Cressman 1959) in GrADS (<http://grads.iges.org/grads>). The 0.5 degree resolution combined with the contouring technique creates a smoothing effect which results in a more generalized, but presumably representative climatology of an area.



From 1977 and 1981, an analysis of the occurrence data indicates that between 20% and 25% of the time in the western United States or Japan or 1 and 2 times (H.M.) had lightning strikes in the region, were caused by clouds grown (C) lightning strikes. Thus, it is desirable to have a better understanding of when and where these lightning strikes occur historically so that the meteorologists and planners can allocate their resources more effectively, and to provide a knowledge base for meteorologists and other users of climate information. Also, this information is necessary in analyzing climate factors related to seasonal the activity (e.g., Brown and Hall 2000, 2001). Since 1989 the National Lightning Detection Network (NLDN) has been recording information about C) lightning strikes across the U.S. The objective of this project was to develop C) lightning strike climatologies over the continental western U.S. for various time periods including the annual average, monthly average, and hourly by month average number of lightning strikes.

Data

Cloud-to-ground lightning strike data for the period 1980 through 2000 were obtained from the National Lightning Detection Network maintained by Global Atmospheric Inc. (GAI). The data are used for the analysis consists of the date, time, latitude, and longitude of the strike. These data are proprietary and were purchased directly from GAI. For further information about NLDN, see Coonen et al. (1999).

Methods

Climatologies for each time period of interest (i.e., annual, monthly, hourly by month) were constructed by dividing the total number of lightning strikes within a grid for the time period by the total number of years (1). The time when the U.S.-Canada border includes these years (1978 - 2000) completely enclose the western Canadian lightning network. When years is a relatively short period of interest for developing a climatology given the occurrence of decadal and longer climate patterns. Also, with such a short record it is possible that a single observation that occurred as "extremely" large amount of lightning strikes could heavily influence the climatology.

A 0.5 degree spatial grid was used across the western U.S. for each climatological time period. This grid was a modification of an arbitrary choice, but it does resolve some oceanic features and allows for identifying coherent regions of lightning activity. Annual correction factors and other for identifying coherent regions of lightning activity. These values for 1978-1998 were applied to each grid to improve the climatology content. These values attempt to correct the known detection efficiency biases across the network during those years based on an algorithm recently developed at GAI (Coonen 2001). Through this correction values are based on a small number of strikes, it is believed that these values can also be applied to the monthly and seasonal climatologies. For the last step of the climatology development, the grid values were summed using a 1 degree spatial resolution scheme (Coonen 1999) in GAI's (proprietary) processing grid. The 0.5 degree resolution combined with the correction technique creates a climatological effect which results in a more generalized, but potentially representative climatology of the area.

## Products Developed

Several graphical displays of the lightning climatology were produced in this project. Specific products include:

- Individual plots of –
  - Annual climatology
  - Monthly climatologies (see Figures 1a, b)
  - Hourly-by-month climatologies (see Figures 2a-d)
- Animations of –
  - Monthly climatologies throughout a year
  - Hourly climatologies (diurnal cycle) for a month

However, due to the proprietary nature of these data, access to the plots is currently limited to wildfire management agencies. Individuals or organizations interested in obtaining lightning data should contact GAI directly (<http://www.glatmos.com>).

Display options include the entire West, or four quadrant regions. On all plots color bars are provided to depict the contour interval. For example, in Figure 1a the intervals are 0-25 strikes, 26-50 strikes, etc. up to greater than 300 strikes. Note that the contour interval may change by month or by region to better highlight activity.

Figure 1 shows an example contoured plot of monthly NLDN lightning climatologies for a) April and b) August based upon the 1990-2000 period. Note the scale change in the contour intervals. For the month of April, the bulk of lightning activity occurs in Texas and western New Mexico. Figure 1b (August) shows that the largest amount of lightning activity occurs over Arizona, New Mexico and Colorado.

Figure 2 shows an example of NLDN hourly lightning climatologies in July for a) 00 UTC (4pm PST), b) 06 UTC (10pm PST), c) 12 UTC (4am PST) and d) 18 UTC (10am PST). In this example, increases in counts are shown at 00 UTC indicating the bulk of lightning activity occurring during the afternoon hours. On the CEFA web site, individual times may be selected, or the user can operate a Java player to animate through the 24-hour period for a given month.

Individual plots and animations for each climatological time period are available at the Desert Research Institute Program for Climate, Ecosystem and Fire Applications web site (<http://www.cefa.dri.edu>).

Several graphical displays of the lightning climatology were produced in this project. Specific products include:

- Individual time of:
  - a. Annual climatology
  - b. Monthly climatology (see Figures 1a, b)
  - c. Hourly climatology (see Figures 2a-d)
- Aggregation of:
  - a. Monthly climatology for throughout a year
  - b. Hourly climatology (diurnal cycle) for a month

However, due to the proprietary nature of these data, access to the plots is currently limited to weather management agencies. Individuals or organizations interested in obtaining lightning data should contact UAL directly (http://www.flightaware.com).

The plot options include the entire West or four quadrant regions. On all plots color bars are provided to depict the contour interval. For example, in Figure 1a the intervals are 4-25 strikes. 25-50 strikes, and up to greater than 100 strikes. Note that the contour interval may change by month or by region to better highlight activity.

Figure 1 shows an example of monthly WLDN lightning climatology for a) April and b) August based upon the 1993-2000 period. Note the scale change in the contour interval. For the month of April, the bulk of lightning activity occurs in Texas and western New Mexico. Figure 1b (August) shows that the largest amount of lightning activity occurs over Arizona, New Mexico and Colorado.

Figure 2 shows an example of WLDN hourly lightning climatology for July for a) 00 UTC (0000 PST), b) 06 UTC (0600 PST), c) 12 UTC (0600 PST) and d) 18 UTC (1000 PST). In this example, lightning is common and shown at 00 UTC indicating the bulk of lightning activity occurring during the afternoon hours. On the CIRA web site, individual times may be selected or the user can create a time plot to examine through the 24-hour period for a given month.

Individual plots and animations for each climatological time period are available at the Internet Lightning Program for Climate, Ecopetrol and Fire Applications web site (<http://www.fireweather.net>).



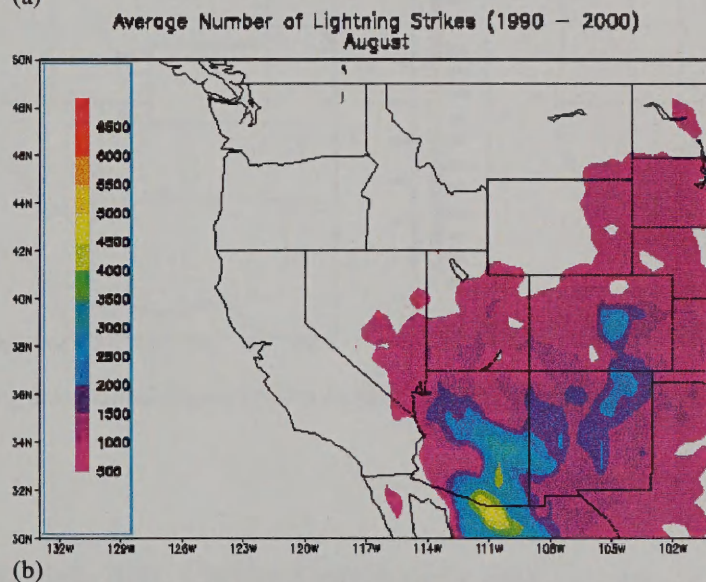
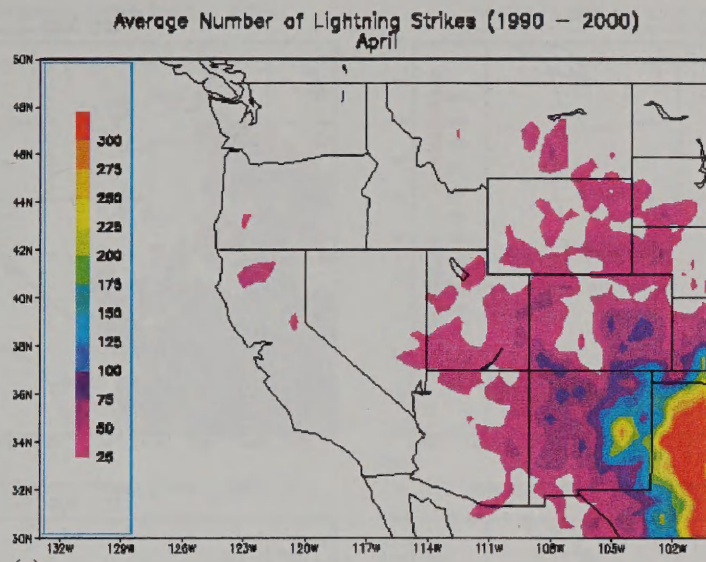
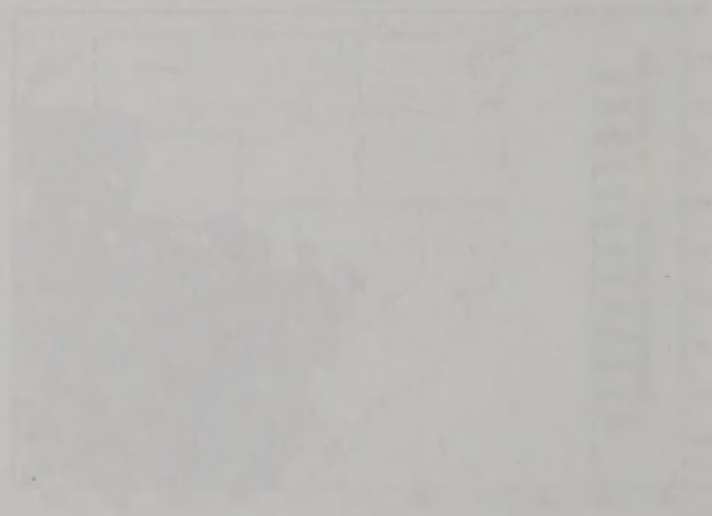
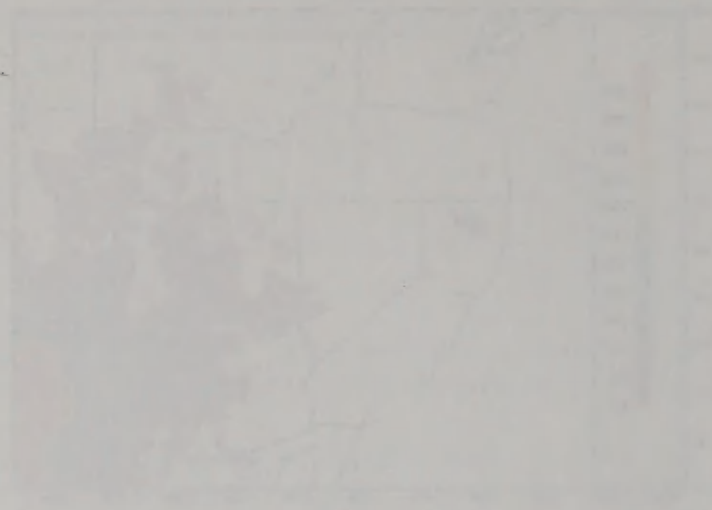


Figure 1: Monthly lightning strike climatology for (a) April and (b) August.



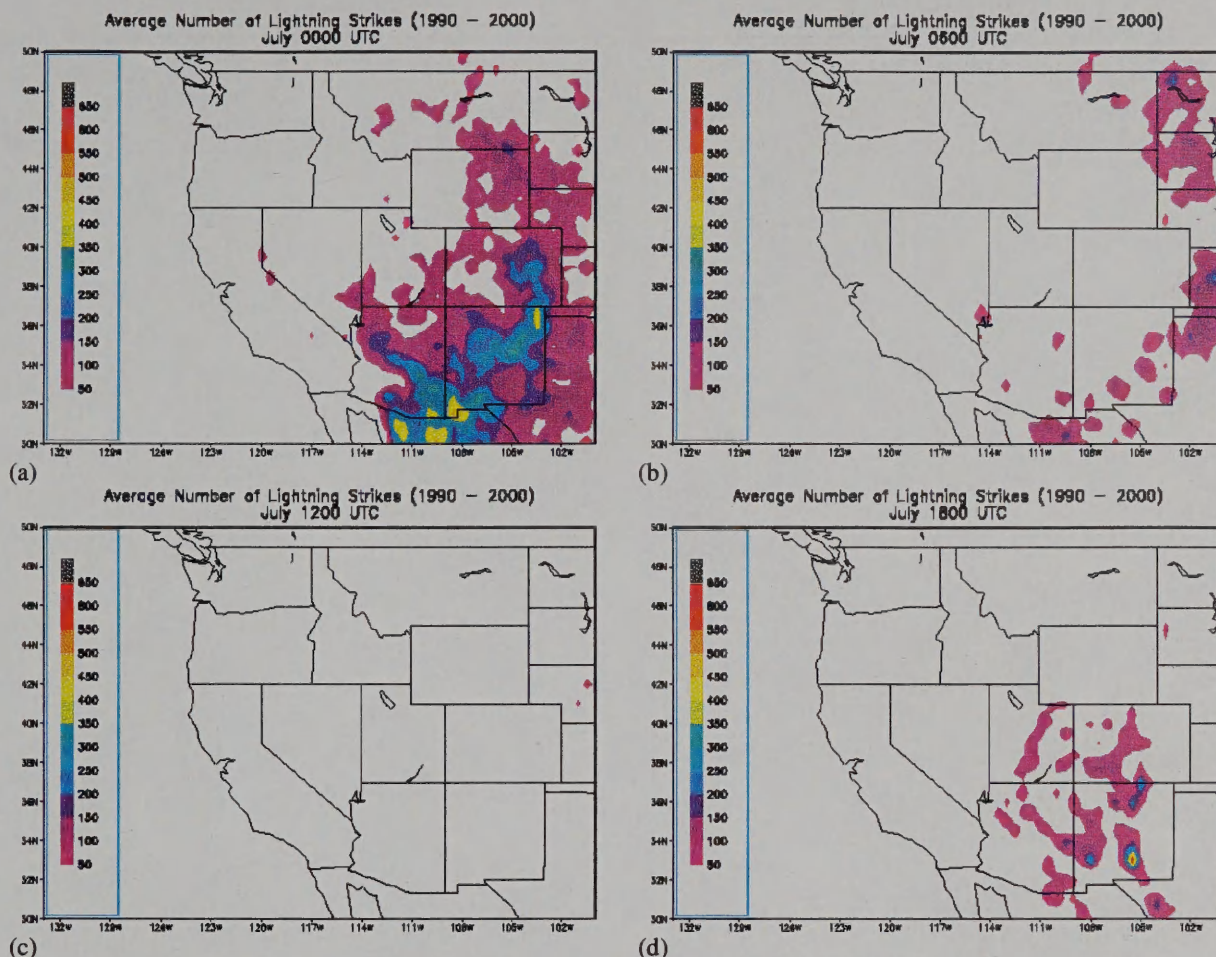


Figure 2: Hourly lightning strike climatologies for July (a) 00 UTC, (b) 06 UTC, (c) 12 UTC, and (d) 18 UTC.

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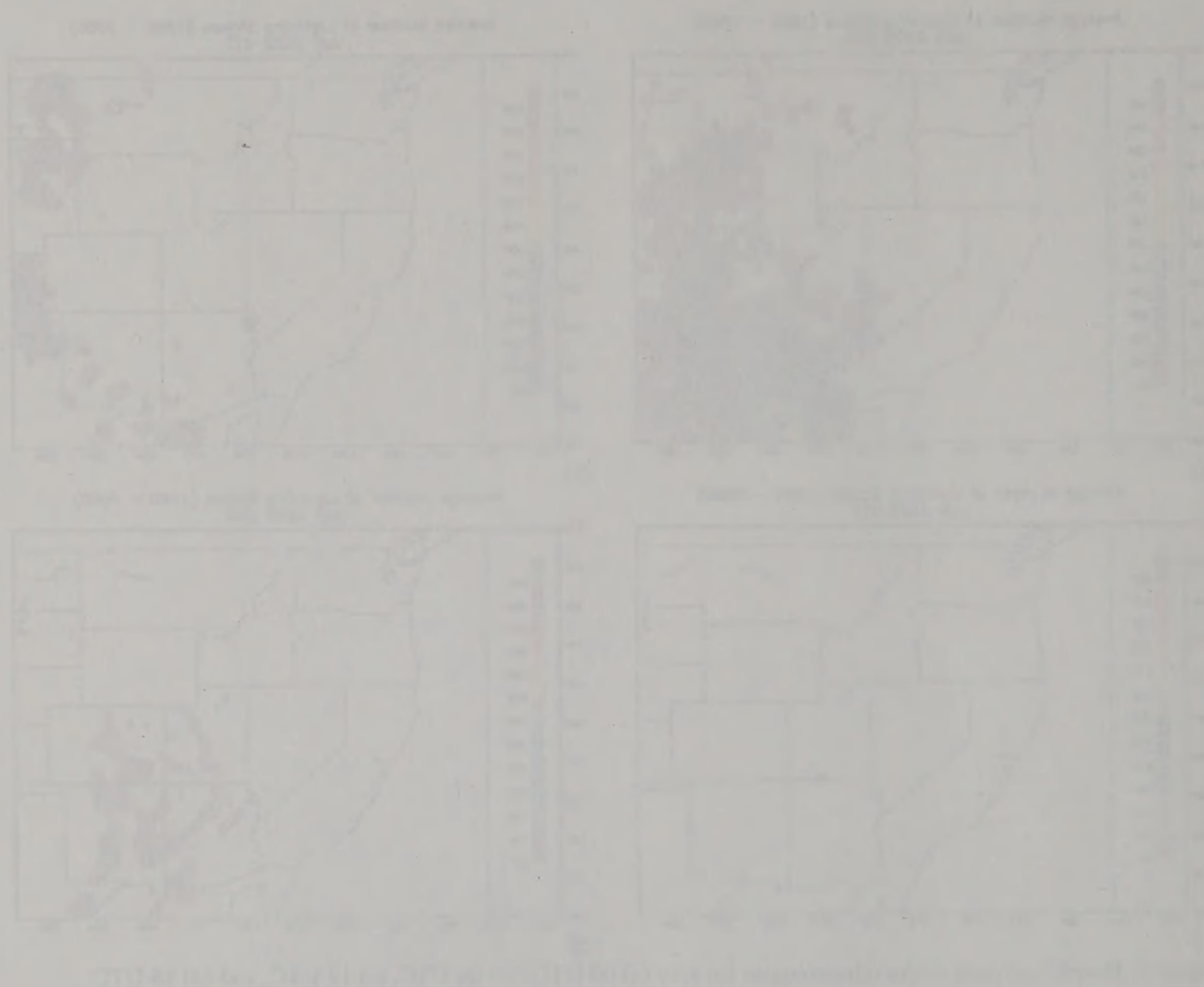


Figure 1. Distribution of the plant species in the western and central US. The numbers 1 through 10 indicate the different species.

Figure 2. Distribution of the plant species in the eastern and southern US. The numbers 1 through 10 indicate the different species.

Figure 3. Distribution of the plant species in the western and central US. The numbers 1 through 10 indicate the different species.

Figure 4. Distribution of the plant species in the eastern and southern US. The numbers 1 through 10 indicate the different species.

UNITED STATES DEPARTMENT OF THE INTERIOR

BUREAU OF LAND MANAGEMENT

Office of Fire and Aviation  
3833 South Development Avenue  
Boise, Idaho 83705

March 01, 2002

In Reply Refer To:  
9210 (FA-620) P

Information Bulletin No. OF&A 2002-035

To: State Directors  
Attn: State Fire Management Officers

From: Director, Office of Fire and Aviation

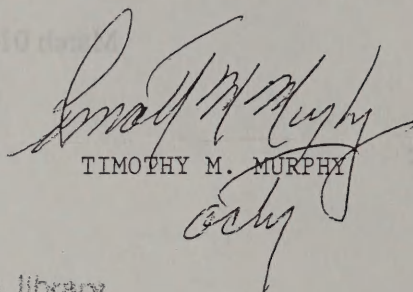
Subject: 2001 Annual Report on BLM/Desert Research Institute Projects and  
Development of Lightning Climatology Information over the Western U.S.

In November, 2000, the BLM began a five-year cooperative Assistance Agreement with the Desert Research Institute's Program for Climate, Ecosystem and Fire Applications (CEFA) in Reno, Nevada. The scope of the Assistance Agreement is climate and ecosystem studies and product development for wildland fire and resource management.

In November, 2001, Climate, Ecosystem and Fire Applications produced its first Annual Report to the BLM, as required under the Assistance Agreement. A copy is enclosed for your review and use. The report describes work performed under the Assistance Agreement to date, including first year progress for each of the original seven Task Orders and other related activities. A review of the Climate, Ecosystem and Fire Applications program is also provided. The document is also available at [http://cefa.dri.edu/Publications/publications\\_index.htm](http://cefa.dri.edu/Publications/publications_index.htm).

Also recently completed under the Assistance Agreement is Task 3: "Development of Lightning Climatology Information over the Western U.S." This project has created lightning climatology products using the National Lightning Detection Network™ lightning dataset. Specific products include individual plots of annual and monthly climatologies and animations of monthly and hourly climatologies (diurnal cycles). These products are described in more detail in Attachment 2 and can be accessed via the web at [http://www.cefa.dri.edu/Cefa\\_Products/cefaprod\\_index.htm](http://www.cefa.dri.edu/Cefa_Products/cefaprod_index.htm).

Questions regarding the Annual Report or "Development of Lightning Climatology Information over the Western U.S." can be directed to Paul Schlobohm, Program Manager, 775-674-7170, or Dr. Tim Brown, CEFA Director, 775-674-7090.

  
TIMOTHY M. MURPHY

2 - Attachments

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1 - Annual Report (15 pp.)

2 - Development of Lightning Climatology Information over the Western U.S. (5 pp.)

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